DUAL-PLANE SEAL FOR FLUID-TIGHT CONDUIT CONNECTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a device for improved sealing of a conduit connection. More particularly, the present invention relates to a dual-plane sealing configuration for connecting a tube to a port within an automotive air-conditioning component.

2. Description of the Prior Art

Prior to the present invention, many types of sealing configurations have been proposed for connecting a tube to another component of a fluid system. Perhaps most common was the use of a simple O-ring encircling an end of a tube mounted into a port. The tube would be connected to the port using a coaxial fastener that encircled and entrapped the tube. The coaxial fastener would then be screwed down over corresponding threads on the port—similar to a compression fitting—as is known in the art. Although this configuration was very simple and robust against leakage, its primary drawback was that it could not be assembled quickly enough for the modem day assembly line. In order to torque the fastener to the female port it was necessary to use hand tools, which was too time consuming. Therefore, devices such as teardrop block connections were developed.

The teardrop block connection involves a small mounting block having a teardrop-shaped profile. The teardrop block entraps the conduit through a conduit passage therein. Also, the teardrop block houses a fastener through another passage just offset from and parallel to the conduit passage. A simple bolt-style fastener is used to draw the teardrop block and conduit to the port, where the connection can be fastened quickly with a power tool. However, the teardrop block connection tends to be more susceptible to leakage than the coaxial fastener connection.

Accordingly, there are several reasons that teardrop block connections tend to leak. First, for packaging considerations, conduit ends are typically made very short to minimize the corresponding length of the port. As a result, the short conduit end tends not to pilot within the female port as well as a longer pilot would. Second, during final torque-down the teardrop block and conduit tend to misalign, cross-axially, relative to the female port. This misalignment is often the result of the cantilever nature of the teardrop design. That is, since the longitudinal axis of the fastener is not coaxially aligned with the conduit, but is instead offset, any torquing of the fastener often imparts a cantilever effect across the teardrop block. The cantilever effect results in a maximum hold-down force along the axis of the fastener and a minimum hold-down force at the opposite end of the teardrop block at the far edge of the conduit. Therefore the mounting block often does not mount squarely to the sealing surface and likewise the conduit does not mount squarely within the port. Such cross-axial misalignment results in slight abrasion to or insufficient "squeeze" on the O-ring, thus permitting fluid to leak by. Accordingly, such fluid leaks present a significant warranty problem to automobile manufacturers.

In response to this problem, component manufacturers have, in some applications, applied a gasket between the teardrop block and the port. FIGS. 1 and 2 illustrate a gasket 60P according to the prior art. Here, interference tabs 67P are used to help retain the gasket 60P around the conduit during shipping and assembly. However, while such a gasket may reinforce the sealing potential of the connection, the

gaskets of the prior art introduce new problems. Because the gaskets are stamped from metal substrate, the interference tabs scratch and thereby create leak paths along the outer surface of the conduit as the gasket is assembled thereto. Furthermore, such gaskets incorporate no feature to counteract the inherent cantilever misalignment of typical end-form connections.

From the above, one can see that an improvement in the capability to seal a teardrop-shaped fluid connection is required. Therefore, what is needed is a sealing configuration that minimizes misalignment of the connection and incorporates additional areas of sealing within the connection.

SUMMARY OF THE INVENTION

According to the present invention there is provided a device that minimizes assembly misalignment and incorporates additional areas of sealing within the fluid-tight conduit connection. The fluid-tight conduit connection includes a conduit having a circumferential groove with a circumferential seal mounted therein. Further, an end-form block has a conduit passage through which the conduit is fitted and entrapped. Likewise, a planar seal has a formed pilot with an aperture through which the conduit is fitted. Furthermore, a receiver has a fluid passage into which the conduit is fitted, where the circumferential seal is compressed between the fluid passage and the conduit to establish a first primary seal. Similarly, the planar seal is compressed between the receiver and the end-form block to establish a second primary seal, and the formed pilot is sandwiched between the conduit and the receiver to establish a secondary seal. Finally, fastening members are included for fastening the end-form block to the receiver such that the planar seal is further compressed to complete the fluid-tight connection.

Additionally, the planar seal may include an embossment surrounding the aperture and following the periphery of the planar seal to establish a preload on the planar seal during assembly of the fluid-tight conduit connection. Similarly, the embossment may be greater in thickness near one end of the fluid-tight conduit connection than at an opposite end, so as to pre-seal one end of the fluid-tight conduit connection during assembly. Furthermore, the fastening members may include a stud and fastening nut with a conically-shaped washer overhanging the end-form block, to counterbalance alignment during assembly.

From the above, it can be seen that a significant advantage of the present invention is the introduction of an additional sealing area within the traditional conduit connection. The formed pilot of the planar seal provides the additional sealing area, thus establishing a secondary seal, in addition to the first and second primary seals.

Additionally, the conduit connection may include features that balance alignment of the end-form block and conduit to the receiver, thereby minimizing potential for leakage. The embossment of the planar seal or the conically-shaped oversize washer of the fastening members are features that counteract the inherent cantilever nature of an endform block connection.

Accordingly, it is an object of the present invention to provide an improved configuration for sealing a conduit connection.

It is another object of the present invention to provide a fluid-tight conduit connection with a planar seal that assembles smoothly over an end of a conduit without leaving scratches and leak paths on the conduit.

It is yet another object of the present invention to provide a fluid-tight conduit connection with a planar seal that yields

an additional sealing area in the form of a formed pilot pinched between a receiver and an end-form block.

It is a further object of the present invention to provide a fluid-tight conduit connection with a planar seal that has a feature to help align a conduit to a port and counteract the inherent cantilever nature of an end-form block connection.

Additional objects, features, and advantages of the present invention will become apparent from a reading of the detailed description of the preferred embodiment taken in conjunction with the drawings appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of a planar seal according to the prior art wherein three equally spaced interference tabs are formed integral with an aperture;

FIG. 2 is a front view of FIG. 1;

FIG. 3 is an exploded perspective view of a fluid-tight conduit connection in accordance with the present invention;

FIG. 4 is an end view of the exploded fluid-tight conduit connection of FIG. 3;

FIG. 5 is a cross-sectional assembled view of the fluid-tight conduit connection of FIG. 4, taken along line 5—5 thereof;

FIG. 6 is an enlarged section of circle 6 of FIG. 5;

FIG. 7 is a top view of a planar seal according to the present invention;

FIG. 8 is a cross-sectional view taken along line 8—8 of FIG. 7;

FIG. 9 is an enlarged cross-section of circle 9 of FIG. 8;

FIG. 10 is a cross-sectional view of a typical fluid-tight conduit connection prior to final torque down;

FIG. 11 is a cross-sectional view of a typical fluid-tight conduit connection after final torque down;

FIG. 12 is a top view of an alternate embodiment of the planar seal of the present invention;

FIG. 13 is a cross-sectional view of another alternate embodiment of the planar seal of the present invention; and

FIG. 14 is a cross-sectional view of a conduit connection just prior to torque-down and incorporating the planar seal of FIG. 12.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Disclosed is a device for sealing a fluid-tight conduit connection in an automobile air-conditioning system in which a novel gasket prevents refrigerant leaks. More specifically, the novel gasket incorporates a self-sealing aperture and pre-load or pre-seal features so as to form additional, more reliable seal areas.

While the present invention will be described in detail with respect to an automobile air-conditioning system, the present invention is also well suited to other applications, including but not limited to: steering, braking, and hydraulic systems; coolant lines; and other similar applications. Additionally, the novel gasket is depicted below in combination with an O-ring but may be effectively used as a sole sealing device. Furthermore, the term conduit covers tube, pipe, hose, and other conduit regardless of material. Accordingly, the present invention is not limited to only an automobile air-conditioning system.

Referring now in detail to the Figures, there is illustrated in FIG. 3 an exploded view of an improved conduit connection **10** in accordance with the present invention. The conduit connection **10** primarily includes an end-form assembly embodying a conduit **20** entrapped within an end-form block **40**, and further includes a planar seal such as a gasket **60** and a circumferential seal such as an O-ring **30** that seats in a circumferential groove **28** (shown in FIG. 5) in the conduit **20**. The end-form assembly is inserted into a receiver **80** such as a female block or housing, and fastened down using a fastener such as a bolt, or a stud **90** and nut **92** combination.

Referring now to FIGS. 4 through 6, the conduit connection **10** of FIG. 3 is illustrated in assembled form. As best illustrated in FIG. 4, the conduit connection is preferably teardrop-shaped, but may take any other appropriate form. FIGS. 5 and 6 illustrate the end-form block **40** having a sealing surface **42** opposite a fastening surface **44** with a conduit passage **46** therebetween. The conduit passage **46** includes a counterbore **48** in the sealing surface **42** and also has a front chamfer **50**. The passage further includes a rear chamfer **52** in the fastening surface **44** and also includes axial grooves **54** extending therethrough. The conduit **20** is formed tightly to the conduit passage **46** by inserting an end **22** of the conduit **20** into the conduit passage **46** and axially compressing the conduit **20** therein to form an upset bead **24** in the counterbore **48** to hold the conduit **20** to the end-form block **40**. Consequently, a pilot diameter **26** and the circumferential groove **28** are formed between the end **22** and the upset bead **24** of the conduit **20**.

Maintaining the upset bead 24 flush with or slightly higher in relation to the sealing surface 42 of the end-form block 40 is critical to the success of forming the fluid-tight seal. Accordingly, a unilateral height tolerance of 0.000" to 0.004" is maintained. Use of a thicker gasket than is shown in FIGS. 5 and 6 would permit a greater tolerance and possibly a negative bead height relative to the sealing surface **42**. This configuration ensures that the upset bead will sufficiently compress or "pinch" the gasket at a pinch-point **63**, to guarantee sufficient compression to complete the second primary seal, as seen in FIG. 6. As is known in the art, during end-forming a punch (not shown) strikes the conduit **20** and the end-form block **40** to compress the upset bead **24** flush with the sealing surface **42**. In order to accommodate such a tight tolerance several features have been incorporated.

First, excess conduit material from the upset bead **24** forming would otherwise result in exceeding the 0.004" maximum dimension. Therefore, the front chamfer **50** is provided in the sealing surface **42** to enable excess conduit material to flow therein in order to maintain the tight unilateral tolerance. Second, the rear chamfer **52** is provided in the fastening surface **44** for flow of conduit material during the end-forming process. Third, the axial grooves **54** are provided for three reasons. One, conduit material interlocks with the axial grooves **54** to prevent relative rotation. Two, like the front and rear chamfers **50/52**, the axial grooves **54** help take up excess conduit material to help meet the tight unilateral tolerance. Three, the axial grooves **54** permit fluid pressure and trapped air built up during compression to escape out the rear chamfer **52** and blow by the thin excess conduit material. This helps conduit material to flow during the end-forming process.

Still referring to FIGS. 5 and 6, there is illustrated the gasket **60** having a peripheral or circumferential edge **61**, a front surface **62**, a rear surface **64**, and an aperture **66** therebetween. Surrounding the aperture **66** is a crown or formed pilot **68** as best seen in FIG. 6. The aperture **66** mounts over the end **22** of the conduit **20** onto the pilot diameter **26**. Further, the receiver **80** has a sealing surface **82**

with a fluid passage 84 therein having a chamfer 86. The conduit 20 mounts into the fluid passage 84 so that the gasket 60 mounts flat to the sealing surface 82 and so that the formed pilot 68 fits tightly between the conduit pilot diameter 26 and the receiver chamfer 86. Furthermore, the O-ring 30 is compressed between the circumferential groove 28 and the fluid passage 84 to form the first primary seal of the conduit connection 10. Finally, the conduit connection 10 is fastened together using the stud 90 passed through a fastener passage 56 and threaded into a threaded passage 88 in the receiver 80. The nut 92 torques down over the stud 90 to compress the gasket 60 around the upset bead 24 and at the formed pilot 68 to form the second primary seal and secondary seal, respectively.

FIGS. 6 through 9 best illustrate the gasket 60 of the present invention. The gasket is also preferably teardrop-shaped and made of a substrate 70 sandwiched between rubber coating 72. The substrate 70 is preferably aluminum but may be composed of any appropriate material. The rubber coating 72 is preferably nitrile but also may be composed of any appropriate material for sealing liquids or gases. At least one formed embossment 74 encircles the aperture 66 and continues on to surround a fastener hole 76. The embossment 74 serves to balance assembly alignment by pre-loading the conduit connection (not shown) and thereby ensuring contact and sealing around the entire periphery thereof, against fluid leakage.

As is shown, the formed pilot 68 encircles the aperture 66. FIGS. 6 and 9 highlight the fact that, unlike the prior art, the gasket 60 of the present invention will not damage the pilot diameter or circumferential groove of the conduit (not shown). This is because the aperture 66 introduces no bare base material edge to the sensitive conduit. Instead, due to the geometry and rubber material of the formed pilot 68, the aperture 66 slides smoothly over the conduit (not shown). Therefore, no leak paths are generated from damage caused by any bare base material edge that may be left over from a stamping process. Additionally, the formed pilot 68 serves as a secondary seal where it is pinched between the conduit pilot diameter 26 and the receiver chamfer 86 as shown in FIG. 6. Further, the formed pilot 68 helps center the conduit to the port (not shown). During assembly, a tapered surface 78 on the formed pilot 68 contacts the chamfer in the fluid passage of the receiver (not shown). This helps keep the conduit 20 centered, thereby reducing side-loading and enabling a better and longer lasting fluid-tight seal.

FIG. 10 illustrates the conduit connection 10 prior to final torque-down in an appropriately aligned condition. However, as is known in the art, during final torque-down the conduit connection 10 can become slightly misaligned as shown in FIG. 11. FIG. 11 illustrates the cantilever behavior of teardrop-shaped connections: that is, the farther away from the centerline of the stud 90 and a nut 91, the less hold down force there is. Normally, hold down force will be at a maximum near a fastener end 12 of the conduit connection 10 and at a minimum at a conduit end 14. This imbalance in hold down force can result in the exaggerated gap evident at the conduit end 14 of the conduit connection 10. The imbalance also causes misalignment of the pilot diameter 26 and O-ring 30. Therefore, a few alternative embodiments are discussed below that address this problem.

The first alternative embodiment to address the cantilever misalignment problem is illustrated in FIG. 10. Here the nut 92 is illustrated having a conical swivel washer 93. The conical swivel washer 93 has a radius greater than the radius of the connecting block at the fastener end. The outer diameter of the conical swivel washer 93 engages the fastening surface 44 between the fastener axis and the conduit axis but overhangs the end-form block 40 at the fastener end 12, as best seen in FIG. 4. This differential in engagement area results in a shift in the location of maximum hold down force from the fastener axis to a location somewhere between the fastener axis and the conduit axis. This shift in location thereby serves to decrease the cantilever of the conduit connection 10, improve assembly alignment, and increase sealability of the connection.

Similarly, FIG. 12 illustrates a gasket 60' that improves alignment, not by decreasing the cantilever effect, but instead by counterbalancing it. Accordingly, the gasket 60' incorporates fold-over tabs 75' near a fastener hole 76'. The fold-over tabs 75' are folded onto the gasket 60' before it is assembled with the other components, thereby creating a double layer of gasket material. FIG. 14 illustrates this gasket 60' as assembled to the conduit connection 10'. The fold over tabs 75' must be located outboard of the transverse centerline of the fastener hole 76' at the fastener end 12' of the conduit connection 10', as shown in FIG. 14. The fold-over tabs 75' act to pre-load the fastener end 12' of the conduit connection 10' and thereby counteract the cantilever and compensate for the inherent imbalance of axial force on the far conduit end 14'. Consequently, appropriate alignment is achieved, as seen in FIG. 5.

Likewise, FIG. 13 also illustrates a gasket 60" according to an alternative embodiment of the present invention. This gasket 60" incorporates a modified embossment 74" that is formed higher at the conduit end 14" than at the fastener end 12". Unlike the configuration of the gasket 60' of FIGS. 12 and 14, this gasket does not counterbalance the cantilever effect, but instead pre-seals the conduit end 14" to counteract the cantilever effect.

Accordingly, a significant advantage of the present invention is that a significantly lower leak rate of the conduit connection is realized. This is a result of using a conduit connection that incorporates features such as a gasket having a formed pilot, a gasket having anti-cantilever features, and an anti-cantilever fastener. To evaluate the decrease in leak rate that can be achieved in accordance with the present invention, the applicants developed and completed a series of thirty-day, 24 hour/day leak rate tests. The tests included daily temperature variations from 127° C. (260° F.) to −40° C. (−40° F.) with varying vibration inputs to the connectors. One pair of tests compared a group of HNBR O-ring conduit connections against a group of dual-plane seal conduit connections that each had an HNBR O-ring and a nitrile axial sealing gasket. Both tests used ½" tube connections on the high side of the system, similar to FIGS. 3 through 6. Also, both tests were performed using HFC R134a refrigerant. Leak rate data was captured at 127° C. (260° F.) averaging 3172 kPA (460 psi), otherwise known as "worst case customer usage condition", and also at 100° C. (212° F.) averaging 2690 kPA (390 psi). Finally, the tests were performed using a gas analyzer with measurement accuracy of +/−0.2 grams/year.

The first test evaluated the prior art gasket by comparing conduit connections with only a single O-ring against conduit connections with a single O-ring and a nitrile coated aluminum gasket having a double embossment and interference tabs as shown in FIGS. 1 and 2. At 127° C. the single O-ring samples averaged 7.2 g/yr, and the gasket/O-ring samples averaged 4.2 g/yr—for a reduction of 42%. At 100° C. the single O-ring samples averaged 2.8 g/yr while the gasket/O-ring samples averaged 0.6 g/yr—for a reduction of 79%.

Next, the second test evaluated the novel gasket by comparing conduit connections having only the single